INSTITUTE FOR DEFENSE ANALYSES

Predicting Disposal Costs for United States Air Force Aircraft (Presentation)

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Western Economics Association International

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IDA | # Outline

- Background
- Research Approach
- Aerospace Maintenance and Regeneration Group (AMARG) Process Model
- Model Assumptions
- AMARG Data
- IDA Model and Regressions
- Conclusions

IDA | Background

Life cycle cost estimates for USAF aircraft include disposal of assets, but little information is available on how to estimate disposal costs in cases in which disposal of assets is not imminent.

<u>Storage Status</u>

- 1000: War Reserve
- 2000: Parts Reclamation
- 3000: Flyable Hold
- 4000: Disposal Prep

“The Boneyard” – Davis-Monthan AFB

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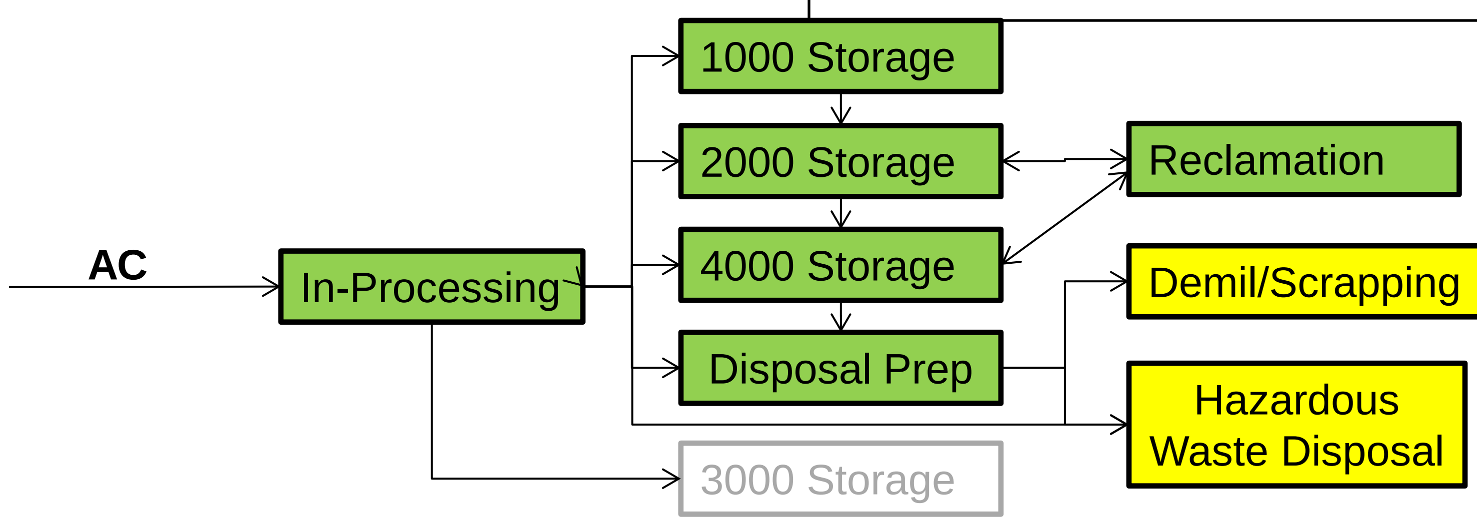
Research Approach

- Develop Disposal Life Cycle Cost Work Breakdown Structure (WBS) based on AMARG disposal process
- Collect AMARG data
  - Only able to obtain last 10 years of data
  - Revenue and labor rates
    - Overhead was included in labor rates
- Identify systems for which adequate data existed to perform regression analysis
  - Use labor hours as basis for regression analyses and cost model

IDA | AMARG Process Model

- AMARG in-processes ~200 AC/year
- ~4000 aircraft on site at AMARG
- Storage for ~20 years
  - Maintenance occurs 2 times/year
- Category 1000 for ~10 years (“re-preservation” every 4 years)
  - Each aircraft will see re-preservation twice
- Category 2000/4000 for ~10 years

- Other Factors
  - Peculiar support equipment (PSE) is disposed of separately
  - Storage of production tooling disposed of separately
  - Ordnance and weapons removed before arrival at AMARG
  - In-process includes initial HAZMAT removal (fuel, coolants, explosives)
  - Engines are stored/disposed of with aircraft
  - Major HAZMAT removed at disposal preparation



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IDA Disposal Life Cycle Cost Model Assumptions

- Disposal Model Assumptions:
  - 1 in-process and 1 disposal prep project/tail
  - 2 in-storage maintenance projects/tail/year
    - t_s years in storage (nominal value of 20)
  - Aircraft are in inviolate (War Reserve) storage (1000 category) for t_i years (t_i can be 0 if the aircraft is never in 1000 status)
  - Re-preservation (rp) occurs every 4 years
    - A total of Nrp times (nominal value of 2)
- Reclamation Assumptions:
  - Programmed/savelist reclamation: 1 per tail
  - Priority reclamation: Analysis indicates P(x) ≈ 0.05 based on total in storage

IDA | AMARG Data

- Data
  - Tail number (aircraft serial number)
  - Mission design
  - Work phase (in-process, storage, etc.)
  - Work hours
  - Revenue

AMARG Process – Labor Hour Distribution	
Disposal Phase	**Hours**
Process-In	35%
Storage Maintenance	6%
Re-Preservation	15%
Disposal Prep	27%
Parts Reclamation	17%

IDA | IDA Disposal Life Cycle Cost Model

Predicted Cost = Disposal (D) + Reclamation (R)

D=PI+S+R+D,

where

PI = process-in hours (1 time event)
S = storage maintenance hours (2x**s** per year during time in storage)
R = re-preservation hours (2x**r** during time in storage)
D = disposal preparation hours (1 time event)

R = sl + P(x)*t_s*pr,

where

sl = programmed/savelist (1 time event)
pr = priority reclamation, P(x) =.05 and t_s = years in storage

- All regressions in labor hours
- Independent labor rate applied

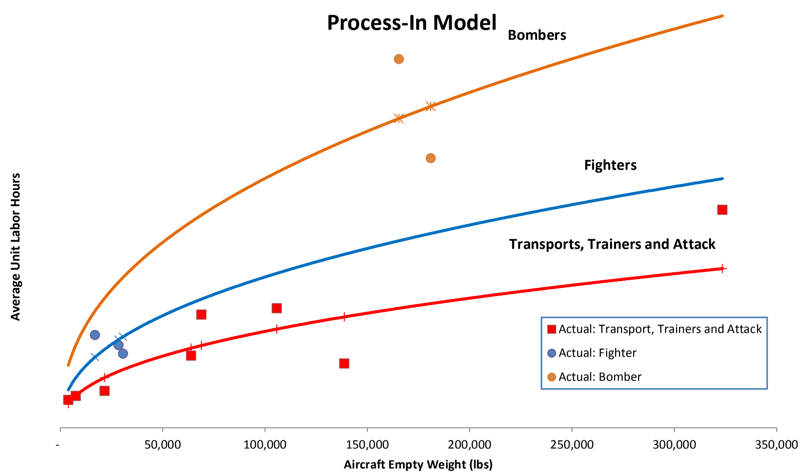
The IDA Model is flexible and can be adjusted to reflect number of years in storage, re-preservations, labor rates, etc.

One-Time Event Regressions

OLS, Dependent Variable is Average Labor Hours for each Mission-Design (e.g., F-16)

Process-In

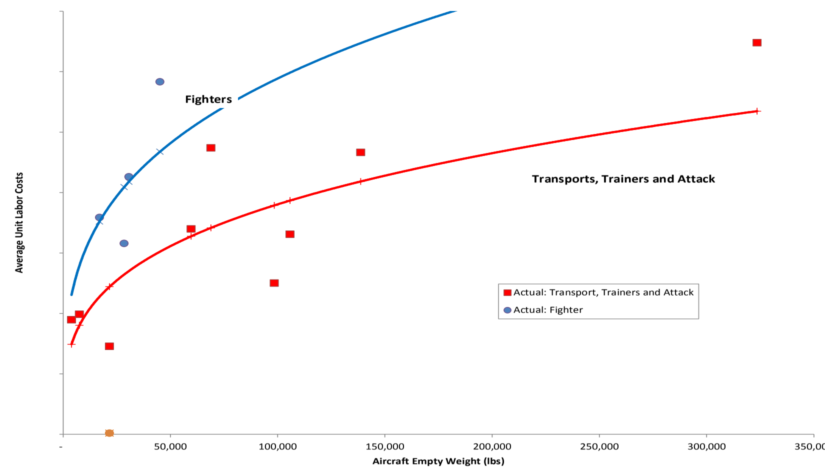
$$\text{PI} = 1.99\, Weight^{0.428}\, 2.59^{Bomber}\, 1.56^{Fighter}$$



Regression Metric	Resulting Value
R^2	0.89
Adjusted R^2	0.85
Standard Error of the Estimate ($\hat{\sigma}$)	0.31
$\hat{\sigma}$ expressed as +/- percentages	+36%/-26%
p value (baseline – other)	<0.01
p value (bomber)	<0.01
p value (fighter)	<0.10

Disposal Prep

$$\text{D} = 4.25\, Weight^{0.267} \left(\frac{Weight}{Footprint}\right)^{0.425}$$

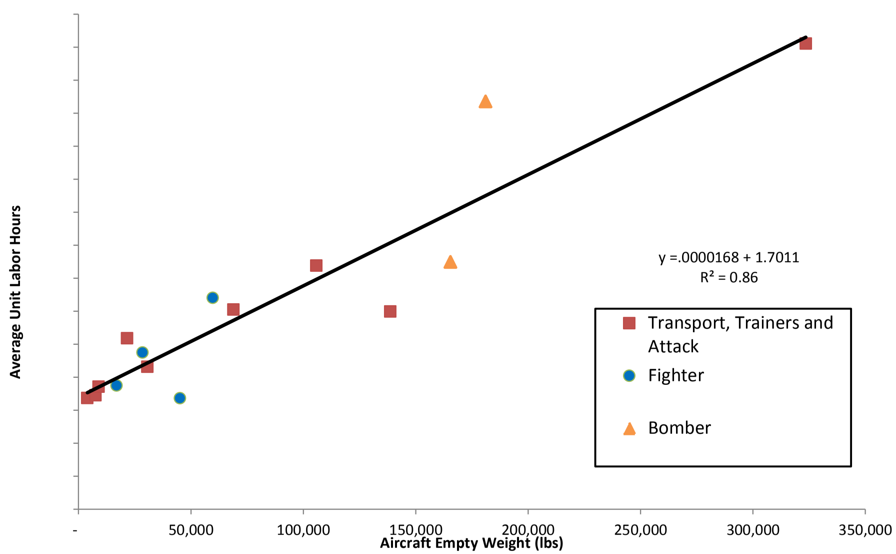


Regression Metric	Resulting Value
R^2	0.68
Adjusted R^2	0.62
Standard Error of the Estimate ($\hat{\sigma}$)	.27
$\hat{\sigma}$ expressed as +/- percentages	+32%/--24%
p value (weight)	<0.01
p value (weight/footprint)	<.05

Recurring Event Regressions

Storage Maintenance

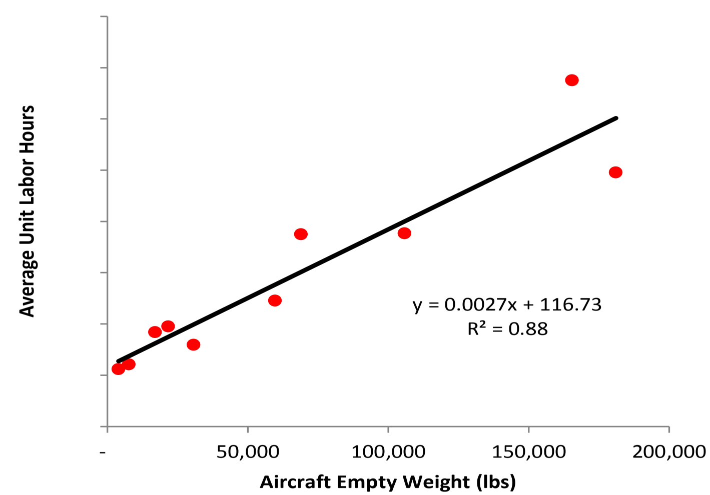
$$s = (1.70 + 0.0000168\,Weight)$$



Regression Metric	Resulting Value
R^2	0.86
Adjusted R^2	0.85
Standard Error of the Estimate ($\hat{\sigma}$)	0.62
Coefficient of Variation	. +/-20
p value (weight)	<0.01

Re-Preservation

$$r = 116.7 + 0.00268\,Weight$$



Regression Metric	Resulting Value
R^2	0.89
Adjusted R^2	0.87
Standard Error of the Estimate ($\hat{\sigma}$)	65.6
Coefficient of Variation	+/-.22
p value (weight)	<0.01

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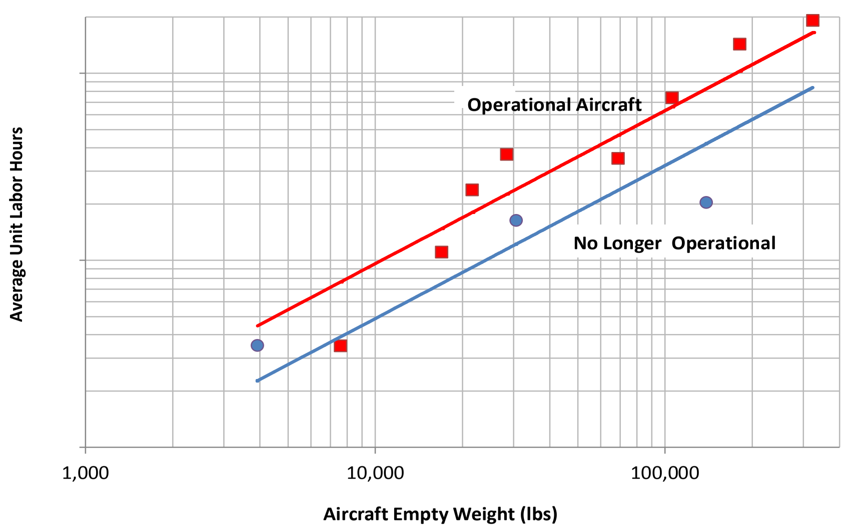
Reclamation Event Regressions

Save List

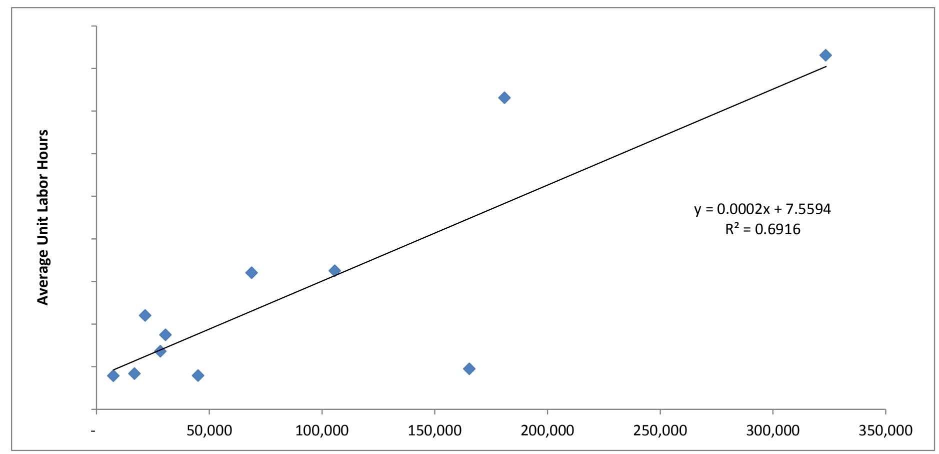
$$\mathbf{sl} = 0.051 * Weight^{0.818} .51^{NO}$$



Regression Metric	Resulting Value
R^2	0.88
Adjusted R^2	0.85
Standard Error of the Estimate ($\hat{\sigma}$)	.51
$\hat{\sigma}$ expressed as +/- percentages	+66%/--40%
p value (weight)	<0.01
p value (no longer operated)	<0.10

Priority Reclamations

$$\boldsymbol{pr} = 7.56 + 0.000225 * Weight$$



Regression Metric	Resulting Value
R^2	0.69
Adjusted R^2	0.66
Standard Error of the Estimate ($\hat{\sigma}$)	15.5
Coefficient of Variation	+/-.55
p value (weight)	<0.01

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Sample Results: IDA Model Estimates for 3 Systems

Step	Hours		
	T-38	F-16	C-130
Process-In	90	200	235
Storage (20 years)	70	80	100
Re-preservation (2x)	265	310	545
Disposal	100	160	135
Sub-total	**525**	**750**	**1015**
Priority Reclamation (1x)	*10*	*10*	*25*
Project Reclamation	*40*	*75*	*240*
TOTAL	**575**	**835**	**1280**

When AMARG labor rates are applied, costs are less than .05% of flyaway costs

However, for a large fleet, total costs could exceed $100M

IDA | Conclusions

- IDA model for estimating future disposal costs
  - Empty weight
  - Mission
  - Density
- Assuming no major changes in AMARG process – future disposal costs can be predicted with sufficient accuracy using the above independent variables
- In terms of total aircraft lifecycle cost, the disposal costs are relatively modest; however, still significant in the aggregate by a given fleet

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14. ABSTRACT
The Air Force Cost Analysis Agency (AFCAA) directed the Institute for Defense Analyses (IDA) to collect data, create databases, and develop innovative methods/tools to better predict future disposal costs for United States Air Force fixed-wing aircraft. IDA created and delivered a cost-estimating tool which was informed by ten years of actual data from the Aerospace Maintenance and Regeneration Group (AMARG). The data used in this study were limited to aircraft currently in the AMARG inventory, but the IDA Cost Estimating Relationships (CERs) allow for estimation of future aircraft disposal costs.
The value of this tool is that it allows AFCAA to quickly see the disposal costs of current aircraft (both total and by phase) as well as to quickly estimate the disposal costs of an aircraft currently in active inventory or of a notional system under development.

15. SUBJECT TERMS
Aircraft disposal, Aerospace Maintenance and Regeneration Group (AMARG), Aircraft disposal cost model, Disposal cost analysis

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